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A pendulum auxotonic lever. By W. D. M. Paton. *Department of Pharmacology, Royal College of Surgeons Examination Hall, Queen Square, London, W.C.*1

For recording movements of isolated organs *in vitro*, attempts are usually made to obtain a lever as light and as nearly isotonic as possible. Although this is generally desirable, in order to obtain the highest sensitivity of the preparation, the lack, with isotonic levers, of a restoring force is sometimes inconvenient, particularly by allowing an irregular base line, or by permitting contractions too large to be recorded. A lightly loaded isotonic lever may also give a misleading idea of the conditions required to produce a maximal contraction, since it determines only the conditions needed to produce complete *shortening* against a slight load.

A number of spring-loaded levers have been described, some with springs strong enough to make the lever approximately isometric. With lighter springs, the lever termed 'auxotonic' (von Frey, 1908) is obtained, in which the load on the muscle increases as it shortens. When the slope of the line relating the load of deflexion is low enough, the lever becomes virtually isotonic. A simpler way, however, of achieving an auxotonic lever is simply to attach a pendulum and bob to the lever. Provided the deflexion of the lever does not exceed about 20° the increase of load with deflexion of the lever is sensibly linear. The main disadvantage incurred is that of increasing the moment of inertia of the lever so that it becomes useless for fast contractions. Such a lever is particularly easily made with C. F. Palmer's Frontal lever made with perforated aluminium strip. A second strip is mounted downwards at right angles to the main lever and is bent at a convenient distance from the fulcrum to make a small support to which weights may be attached.

The characteristics of such a lever are as follows:

(1) It is self-centring and, for a given weight and pendulum length, the load is permanently calibrated in g/cm deflexion on the drum. For a lever length l cm from pivot to writing point, with muscle attached m cm from the pivot, and a pendulum weight w g whose centre of gravity is p cm from the pivot, the load is wp/lm g/cm deflexion, for small angles.

(2) The loading can be easily changed by changing the weight or changing the distance from the fulcrum, and a variety of loads can be rapidly interchanged.

(3) The increase of restoring force with increase in deflexion makes it easier to arrange a preparation so that it both responds to small doses of a drug, and yet the deflexion with maximal doses is not off the drum.

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(4) The restoring force helps to pull out the muscle when a stimulating drug is removed, and abbreviates the time required in restoration of a control base line.

(5) The lever can easily be arranged so that the early part of the contraction is unloaded, but once a given degree of shortening has occurred, an increasing load is then incurred.

In general, the lever is not suited to obtaining large deflexions to very small doses of drugs, although if there is a reserve of sensitivity with an assay tissue, it is then easier to produce regular results. The lever has proved very convenient for studying the extensibility of tissues under the action of drugs.

I am indebted to Professor A. V. Hill for drawing my attention to the early work on the auxotonic lever.

REFERENCE

von Frey, M. (1908). Allgemeine Muskelmechanik. In *Handbuch der Physiologischen Methodik*, ed. R. Tigerstedt. Vol. II, no. 3, pp. 87–119. Leipzig: Hirzel.